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INVESTIGATION OF MACHINING PARAMETERS BY USING PVD COATED TiAlN INSERT AND ALDURA COATED INSERT ON AISI D2 STEEL

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ABSTRACT

AISI D2 steel is the leading candidate material used indies for the production of automobile products and electronic parts. The machinability of the material involves tool life, cutting forces, chip formation with less attention paid to particle emission. In this study, AISI D2 steel was machined (turning operation) using two different tools, namely titanium, aluminum nitride TiAlN coated and ALDURA coated insert. The effect of cutting parameters (cutting velocity, feed, and depth of cut) on machining characteristics (cutting force and surface roughness) were observed. From the machined results the Cutting force generated during ALDURA coated insert machining was lesser than TiAlN coated insert. The surface roughness obtained by ALDURA coated insert was also lesser than TiAlN coated insert. From the above results, it was cleared that ALDURA coated insert has provided better characteristics for machining AISI D2 steel.

Keywords: Turning Operation, TiAlN Coated Insert, ALDURA Coated Insert, Cutting Parameters and Machining Characteristics

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Original Article

INTRODUCTION

Dry, hard turning is a machining process where the hard materials higher than 50 HRC under the cutting range of smaller feed rate and finer depth of cut is turned by using the proper cutting tool without cutting fluids in order to obtain better surface roughness and dimensional tolerances closer to that of obtained by grinding process [1,2]. It has gained more attention because of having the advantages of less machine timing, reduction in manufacturing cost and away from hazards caused by cutting fluids under dry machining compared to grinding [3-5]. Therefore, hard turning is an alternating machining process for grinding process due to its better machinability on hard steel materials [6, 7]. A lot of investigations were made to know the surface roughness and wear rate in machining (turning) operations. Thiele et al. [8] have tested the cutting tool edge with surface roughness during hard machining of AISI 52100 steel. The result showed that the cutting tool having high cutting edge hones provided better surface roughness than cutting tool with smaller cutting hones. Ozel et al investigated hard machining of AISI H13 steel to find the effect of cutting parameters on surface roughness and found that the parameters are significant[9].

Okada et al.[10] reported the tool the performance of tools (CBN and carbide coated PVD) in milling hardened steel. Gaurav Bartarya and S.K. Choudhury [11] have discussed the special circumstances of hard cutting.The investigations focused on the effect of different cutting parameters, tool geometry, tool wear, surface

integrity, the formation of white layer, cutting forces and temperatures, numerical analysis of chip removal process, etc. Even so, there is a large demand to recognize the optimal and well- controlled circumstances for hard machining of different materials. Narutaki and Yamane [12] have investigated the cutting temperature of CBN tools on various hardened steels. The carbide tools have higher cutting temperature than CBN tools depending on the hardness of the workpiece to a certain limit.

Experimental Setup

Table 1: Parameters for Machining

Work Piece Material	AISI D2 Steel
Inserts used	PVD coated TiAlN insert and ALDURA coated insert
Insert Designation	SNMG 120408
Tool Geometry	−6°, 6°, 15°, 75°, 0.8 (mm)
Cutting velocity (v) m/min	100,130,160
Cutting feed (f) mm/rev	0.05,0.10,0.15
Depth of cut (d) mm	0.20,0.40,0.60
Cutting condition	Dry condition

Composition of AISI D2 Steel

Table 2: Composition of AISI D2 Steel

Compound	Cr	C	Mo	W	Si	Mn	Fe
Nominal wt.%	11.8	1.5	0.7	0.6	0.5	0.4	Bal

Tool Designation

Table 3: Tool Specification for Machining AISI D2 Steel

Serial. No.	Cutting Tool	ISO Grade Specification	Composition
1	PVD coated TiAlN insert	SNMG 120408	27.5 % Ti, 28.9 % Al and 43.6 % N
2	ALDURA coated insert	SNMG 120408	TiAlN + AlCrN Based

Modelling of Machining Parameters Using Taguchi Method

A hard turning of AISI D2 steel is carried out in Turn master 35. ISO PSBNR 2525M12 tool holder is used for the experiment. The cutting force of the workpiece is measured using tool post dynamometer (piezo-electric, Kistler Corporation, Model) which is coupled with the amplifier. The surface roughness of the workpiece is measured using Surf coder, Specifications standard: JIS94. The experiment is continued with varying the speed of cutting V_C 100,130 and 160 m/min, and maintaining the constant feed of 0.05 mm/rev and depth of cut 0.20 mm respectively.

Figure 1: Experimental Set up with Dynamometer and Surface Roughness Measurement Setup

Figure 2: Surface Roughness Measurement

Data Sheet for Machining of AISI D2 Steel by TIALN Coated Insert

Table 4: Data Sheet for Machining of AISI D2 Steel by TiAlN Coated Insert

Exp. No	Cutting Parameters			TiAlN Coated Insert	
	Cutting Velocity, (v) m/min	Feed Rate,(f) mm/rev	Depth of Cut, (d) mm	Cutting Force, (Fz) N	Surface Roughness, (Ra) µm
1	100	0.05	0.2	450	3.25
2	100	0.05	0.4	485	2.75
3	100	0.05	0.6	540	2.25
4	100	0.10	0.2	490	3.5
5	100	0.10	0.4	570	3
6	100	0.10	0.6	630	2.85
7	100	0.15	0.2	550	3.75
8	100	0.15	0.4	625	3.6
9	100	0.15	0.6	680	3.4
10	130	0.05	0.2	420	2.45
11	130	0.05	0.4	445	2.3
12	130	0.05	0.6	495	2.2
13	130	0.10	0.2	440	3
14	130	0.10	0.4	470	2.55
15	130	0.10	0.6	510	2.65
16	130	0.15	0.2	540	3.5
17	130	0.15	0.4	575	3.3
18	130	0.15	0.6	620	3.25
19	160	0.05	0.2	390	2
20	160	0.05	0.4	410	1.9
21	160	0.05	0.6	420	1.8
22	160	0.10	0.2	425	2.75
23	160	0.10	0.4	460	2.55
24	160	0.10	0.6	500	2.45
25	160	0.15	0.2	510	3.15
26	160	0.15	0.4	545	2.95
27	160	0.15	0.6	570	2.8

From the above data sheet, the machining characteristics (cutting force and surface roughness) of AISI D2 steel by TiAlN coated insert for the given cutting parameters (depth, cutting speed, and feed rate) were observed.

Data Sheet for Machining of AISI D2 Steel by ALDURA Coated Insert

Table 5: Data Sheet for Machining of AISI D2 Steel by ALDURA Coated Insert

Exp. No	Cutting Parameters			ALDURA Coated Insert	
	Cutting Velocity, (v) m/min	Feed Rate,(f)	Depth of Cut, (d) mm	Cutting Force, (Fz) N	Surface Roughness, (Ra) µm
1	100	0.05	0.2	435	3.15
2	100	0.05	0.4	460	2.55
3	100	0.05	0.6	525	2.1
4	100	0.10	0.2	475	3.3
5	100	0.10	0.4	530	2.85
6	100	0.10	0.6	610	2.4
7	100	0.15	0.2	525	3.56
8	100	0.15	0.4	600	3.45
9	100	0.15	0.6	645	3.16
10	130	0.05	0.2	395	2.1
11	130	0.05	0.4	410	1.85
12	130	0.05	0.6	460	1.75
13	130	0.10	0.2	405	2.8
14	130	0.10	0.4	450	2.3
15	130	0.10	0.6	480	2.15
16	130	0.15	0.2	525	3.35
17	130	0.15	0.4	540	3.1
18	130	0.15	0.6	590	2.89
19	160	0.05	0.2	370	1.95
20	160	0.05	0.4	380	1.6
21	160	0.05	0.6	400	1.46
22	160	0.10	0.2	385	2.3
23	160	0.10	0.4	440	2.05
24	160	0.10	0.6	475	1.89
25	160	0.15	0.2	480	2.9
26	160	0.15	0.4	525	2.65
27	160	0.15	0.6	550	2.46

From the above data sheet, the machining characteristics (flank wear, cutting force and surface roughness) of AISI D2 steel by ALDURA coated insert for the given cutting parameters (depth, cutting speed and feed rate) were observed.

Surface Roughness for Varying Cutting Speed and Depth of Cut

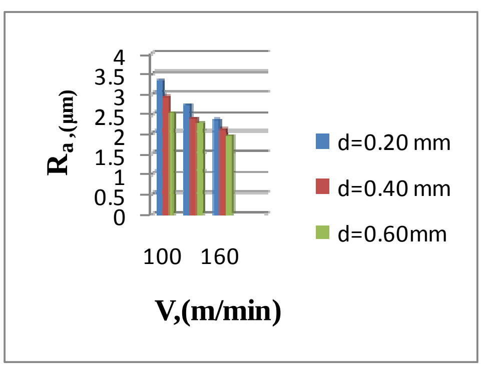

Figure 3: Surface Roughness for Varying Cutting Speed and Depth of Cut for ALDURA Coated Tool

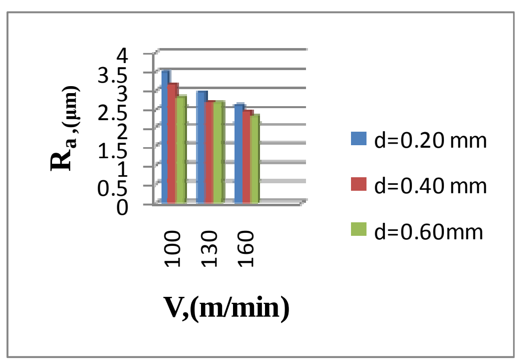

Figure 4: Surface Roughness for Varying Cutting speed and Depth of Cut for TiAlN Coated Tool

From figure 3 and 4, it is seen that Surface roughness is decreased when depth of cut is increased at constant velocity. Which shows an increase in depth of cut with a constant velocity can provide, the better surface quality of the workpiece material.

Surface Roughness for Varying Feed Rate and Cutting Speed

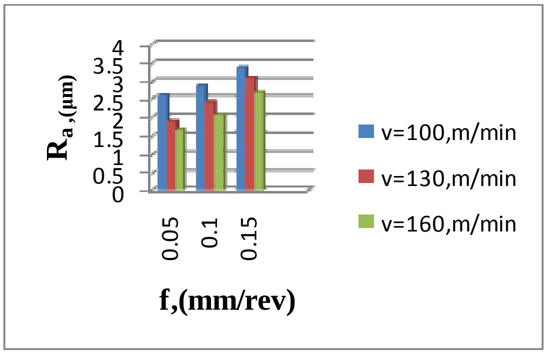

Figure 5: Surface Roughness for Varying Feed Rate and Cutting Speed for ALDURA Coated Tool

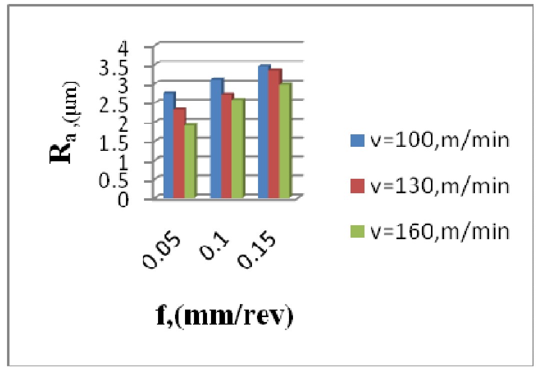

Figure 6: Surface Roughness for Varying Feed Rate and Cutting Speed for TiAlN Coated Tool

From the above figures 5 and 6, When cutting velocity increase there is a decrease in surface roughness at a constant feed. But, compared to the first level there is an increase in surface roughness value in the second level. Which shows feed rate is kept constant, cutting velocity increase, increasing the quality of machining.

Surface Roughness for Varying Depth of Cut and Feed Rate

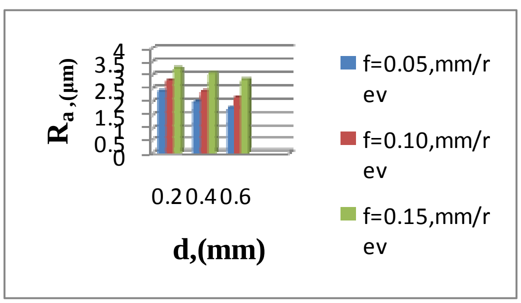

Figure 7: Surface Roughness for Varying Depth of Cut and Feed Rate for ALDURA Coated Tool

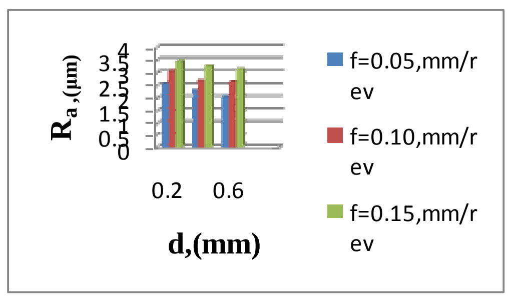

Figure 8: Surface Roughness for Varying Depth of Cut and Feed Rate for TiAlN Coated Tool

Figures 7 and 8 show that, a value of surface roughness is increased when feed rate is increased maintaining the constant depth of cut. But, compared to the first level there is a decrease in surface roughness value in the second level. Which means an increase in feed rate at a constant depth of cut affects the surface quality of workpiece.

Cutting Force for Varying Cutting Speed and Depth of Cut

Figure 9: Cutting Force for Varying Cutting Speed and Depth of Cut for TiAlN Coated Tool

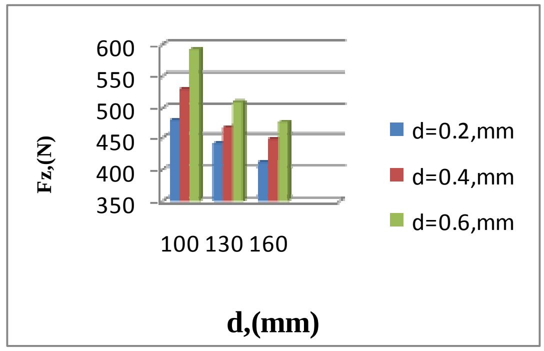

Figure 10: Cutting Force for Varying Cutting Speed and Depth of Cut for ALDURA Coated Tool

From the above figure 9 and 10, it is seen that with an increase in cutting force increases the depth of cut at a constant velocity. But, compared to the first level there is a decrease in cutting force in the second level. Which means an increase in depth of cut with constant velocity can increase the cutting force generated.

Cutting Force for Varying Feed Rate and Cutting Speed

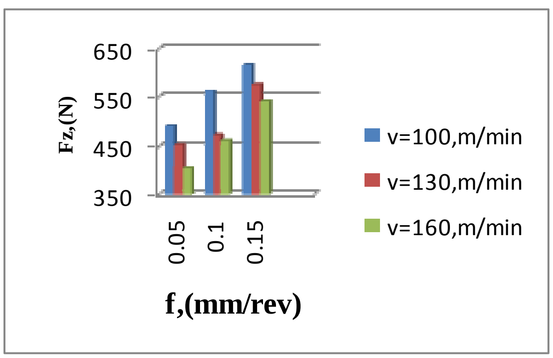

Figure 11: Cutting Force for Varying Feed Rate and Cutting Speed for TiAlN Coated Tool

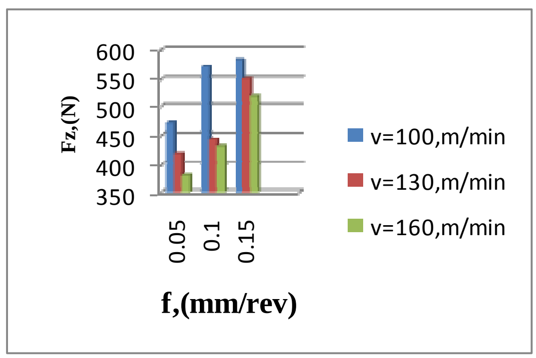

Figure 12. Cutting force for Varying Feed Rate and Cutting Speed for ALDURA Coated Tool

Figures 11 and 12 shows that, value of cutting force decreases with increased cutting velocity at a constant feed rate. But, compared to the first level there is an increase in cutting force value in the second level. This means at the constant feed rate, cutting velocity increases, decreasing the amount of cutting force generated.

Cutting Force for Varying Depth of Cut and Feed Rate

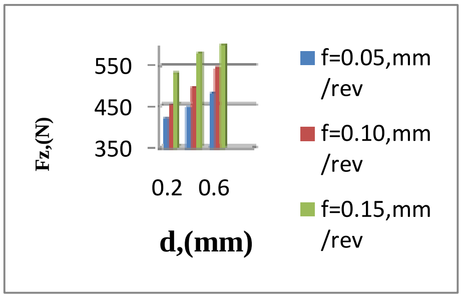

Figure 13: Cutting Force For varying Depth of Cut and Feed Rate for TiAlN Coated Tool

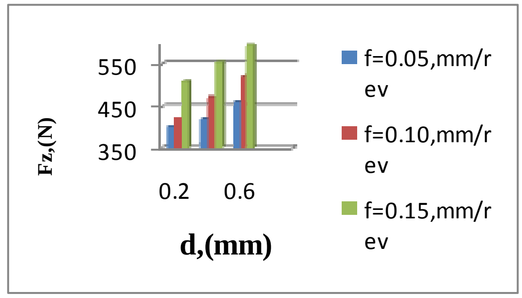

Figure 14: Cutting Force for Varying Depth of Cut and Feed Rate for ALDURA Coated Tool

From the above figures 13 and 14, it is seen that as cutting force increases feed rate also increases maintaining a constant depth of cut. But, compared to the first level there is an increase in cutting force value in the second level. Which means cutting force generated increases with feed rate increase at a constant depth of cut.

Comparative Study of Cutting Parameters Vs. Cutting Force for Both Tools

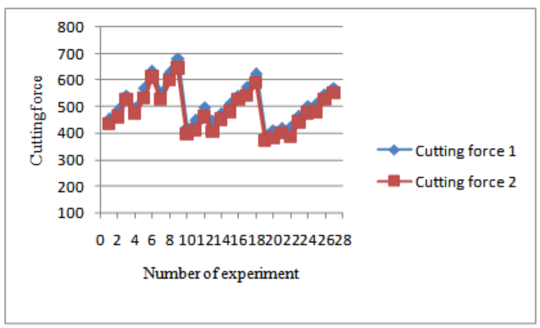

Figure 15: Number of Experiment vs. Cutting Force

From the above chart, cutting force 1 denotes the cutting force of TiAlN for the given cutting parameters and cutting force 2 denotes the cutting force of ALDURA coated insert for the given cutting parameters. It has been observed that cutting force increases with an increase in the range of cutting parameters. But the ALDURA coated insert has delivered less amount of cutting force as compared to TiAlN coated insert. The amount of cutting force should always be low otherwise it causes vibration on the tool, workpiece interface and affects the quality of the workpiece. Hence ALDURA coated insert has found better characteristics in case of cutting force with respect to a given range of cutting parameters.

Comparative Study of Cutting Parameters vs. Surface Roughness for Both Tools

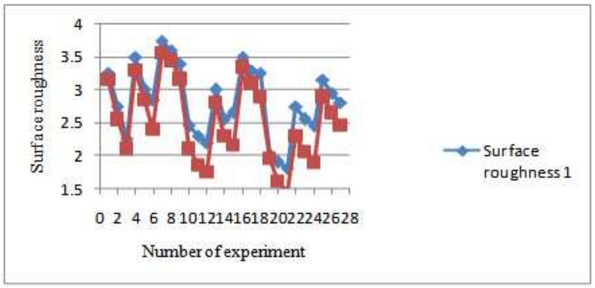

Figure 16: Number of Experiment vs. Surface Roughness

From the above chart, surface roughness 1 denotes the surface roughness of TiAlN coated insert for the given cutting parameters and surface roughness 2 denotes the surface roughness of ALDURA coated insert for the given cutting parameters. It has been observed that surface roughness decreases with an increase in the range of cutting parameters. But the ALDURA coated insert has delivered, lower value of surface roughness as compared to TiAlN coated insert. The amount of surface roughness should always be lesser otherwise it affects the quality of the work piece. Hence ALDURA coated insert has found better characteristics in case of surface roughness with respect to a given range of cutting parameters.

CONCLUSIONS

From the machining results taken from the machining of AISI D2 steel, the following conclusions were drawn. The Cutting force generated during the machining of D2 steel was lesser in case of ALDURA coated insert than TiAlN coated insert. The surface roughness of the D2 steel was good in case of machining with ALDURA coated insert than TiAlN coated insert. From the above conclusion, it was cleared ALDURA coated tool has better characteristics for machining AISI D2 steel were obtained.

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